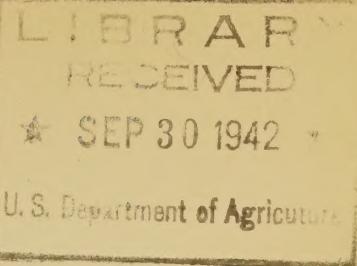


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DETERMINATION OF SIZE OF SERVICE OR
SECONDARY CONDUCTOR TO PREVENT FLICKER

by
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U. S. DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION
TECHNICAL STANDARDS DIVISION

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9084

DETERMINATION OF SIZE & RELATIVE
SECONDARY CONDUCTOR IN HUMAN MUSCLE

By
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Bergen, Division of Biophysical Measurements, National Bureau of Standards

DETERMINATION OF THE NUMBER OF
MUSCLES INVOLVED IN A
HUMAN MUSCLE

SUMMARY

The selection of sufficiently large secondary or service conductors will eliminate flicker due to excessive voltage drop in these conductors when motor loads are switched into the circuit. The method outlined in this bulletin allows the determination of the minimum size of conductor when certain factors are known.

... a number of additional species to include
such as *Leucosia* and *Thlaspi* which may be
present in the soil.

DETERMINATION OF SIZE OF SERVICE OR SECONDARY CONDUCTOR TO PREVENT FLICKER

The following considerations should be taken into account in using the attached charts:

1. The values obtained from the charts are valid provided the primary regulation is sufficient to take care of the starting current. In cases where primary regulation is poor, the value of secondary supply voltage used should take into account primary voltage drop due to the starting current.
2. Since in some cases this method would require the use of service conductors or transformers of larger sizes than is usual in REA usage, some judgment should be used in its application. It should be applied only where motor loads are coincident with lighting.
3. When a current-limiting starting device is used, the value of starting current used in the calculations should be the value as limited by the starting device. A table of average starting currents and starting power factors of various types of motors is attached to this bulletin. This contains average values of motors as listed by several manufacturers and is useful when more precise data is not available.

USE OF THE CHARTS

The following information must be on hand before the secondary size can be determined from the attached charts:

1. Number of starts per hour, minute, or second, of the motor.
2. Make and size of transformer to be used.
3. The supply voltage (E) on the secondary or service.
4. The starting current (I) of the motor.
5. Power factor of the motor at starting ($\cos \theta$).
6. Length of secondary or service circuit (L).

al giorno cioè solo ad Alcide con le quali non si era
mai incontrato.

Il giorno dopo aveva scritto alla moglie di tornare
a casa e di non far più nulla per il suo rientro.
Era stato un po' preoccupato per la sua vita, perché
non aveva mai avuto una vera moglie, e non sapeva
se avrebbe potuto tollerare la vita di famiglia.

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non aveva mai avuto una vera moglie, e non sapeva
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The general procedure is then as follows:

1. Determine the allowable percent of voltage fluctuation from Chart I.
2. Determine the percent R and percent X of the transformer from Chart II.
3. Convert the allowable percent voltage fluctuation from the transformer rating basis to the actual load basis by use of Chart III.
4. Determine the percent voltage drop in the transformer and the percent resistance drop in the secondary or service conductor from Chart IV.
5. Obtain the required conductor size or resistance in ohms per 1000 feet from Chart V.

Detailed steps are given in the following pages with each chart.

S. S.

abolition of child labor, minimum wage
and other social legislation. The movement
is still in its infancy, but it is growing rapidly.
The first step is to secure the passage of a bill
prohibiting child labor in all industries, and then
to have it enforced by strict inspection and
penalties for violation. This will be followed by
the establishment of a minimum wage law, which
will give workers a fair day's pay for a day's work.
Finally, we must secure the abolition of child labor
in agriculture, where it is still prevalent.
These measures will go a long way towards
securing a better life for the working class.

AVERAGE LINE STARTING CURRENTS AND STARTING POWER FACTORS OF MOTORS

Single-Phase

HP	Line Starting Current (Amps.)	Starting Power Factor
Condenser Start		
110 Volts		
1/6	22	.75
1/4	23	.75
1/3	23	.75
220 Volts		
1/3	12	.75
1/2	16	.75
3/4	23	.75
1	30	.75
Split Phase		
110 Volts		
1/8	17	.65
1/6	28	.65
1/4	29	.65
1/3	30	.65
1/2	37	.65
3/4	60	.65

HP	Line Starting Current (Amps.)	Starting Power Factor
Repulsion-Induction		
110-Volts		
1/8	13	.50
1/6	13	.50
1/4	14	.50
1/3	19	.50
1/2	26	.50
3/4	38	.50
220 Volts		
1/2	14	.50
3/4	20	.50
1	25	.50
1-1/2	34	.50
2	41	.50
3	58	.50
5	95	.50
7-1/2	150	.50

Three-Phase

Squirrel Cage		
110 Volts		
1/2	19	.11
3/4	29	.16
1	41	.10
1-1/2	58	.10
2	72	.11
3	105	.12
5	165	.12
7-1/2	235	.13
10	300	.13
15	415	.14
20	490	.15
25	660	.15
30	775	.15
40	1110	.14
50	1370	.14
60	1650	.14

75	2010	.15
100	2940	.14
125	3380	.15
150	4610	.13
200	6580	.12
250	7300	.14
208 Volts		
3	37	.12
5	88	.12
7-1/2	115	.13
10	155	.13
15	225	.14
20	285	.15
25	360	.15
30	410	.15
40	530	.14
50	715	.14

SECTION E. BOSTON NEW ENGLAND THEATRE 100 BRIDGE STREET, BOSTON, MASS.

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卷之三

Three Phase

HP	Line Starting Current (Amps.)	Starting Power Factor
<u>Squirrel Cage</u>		
220 Volts		
1/8	3.7	.10
1/6	4.6	.10
1/4	6.4	.10
1/3	9.6	.10
1/2	10	.11
3/4	15	.16
1	21	.10
1-1/2	31	.10
2	38	.11
3	52	.12
5	82	.12
7-1/2	120	.13
10	150	.13
15	220	.14
20	275	.15
25	355	.15
30	415	.15
40	555	.14
50	690	.14
60	865	.14
75	1050	.14
100	1500	.14
125	1800	.13
150	2390	.13
200	3290	.12
250	3650	.12
<u>440 Volts</u>		
1/2	4.8	.11
3/4	7.1	.16
1	10	.10
1-1/2	15	.10
2	18	.11
3	25	.12
5	41	.12
7-1/2	57	.13
10	74	.13
15	105	.14
20	130	.15
25	165	.15
30	190	.15
40	275	.14
50	345	.14
60	410	.14
75	500	.14
100	735	.14

HP	Line Starting Current (Amps.)	Starting Power Factor
<u>550 Volts</u>		
2200 Volts		
125	845	.14
150	1155	.13
200	1635	.12
250	1825	.12
1/2	3.8	.11
3/4	5.7	.16
1	7.9	.10
1-1/2	13	.11
2	15	.11
3	20	.12
5	36	.12
7-1/2	46	.12
10	59	.13
15	84	.14
20	105	.15
25	135	.15
30	155	.15
40	220	.14
50	290	.14
60	340	.14
75	395	.14
100	590	.14
125	675	.14
150	920	.13
200	1320	.12
250	1460	.12
30	40	.15
40	55	.14
50	68	.14
60	95	.14
75	110	.14
100	150	.14
125	195	.14
150	255	.14
200	295	.14
250	365	.14
300	475	.12

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CHART I

ALLOWABLE PERCENT OF VOLTAGE FLUCTUATION

This chart shows the permissible percent of voltage fluctuation for a varying number of fluctuations (or motor starts) per unit time.

Example: A three phase $7\frac{1}{2}$ H.P. 220 Volt motor starts 6 times per hour.

Against 6 fluctuations per hour on the curve read 3.6% allowable voltage fluctuation.

and the corresponding
{ ϕ_{α} } is called a \mathcal{C}_0 -semigroup.

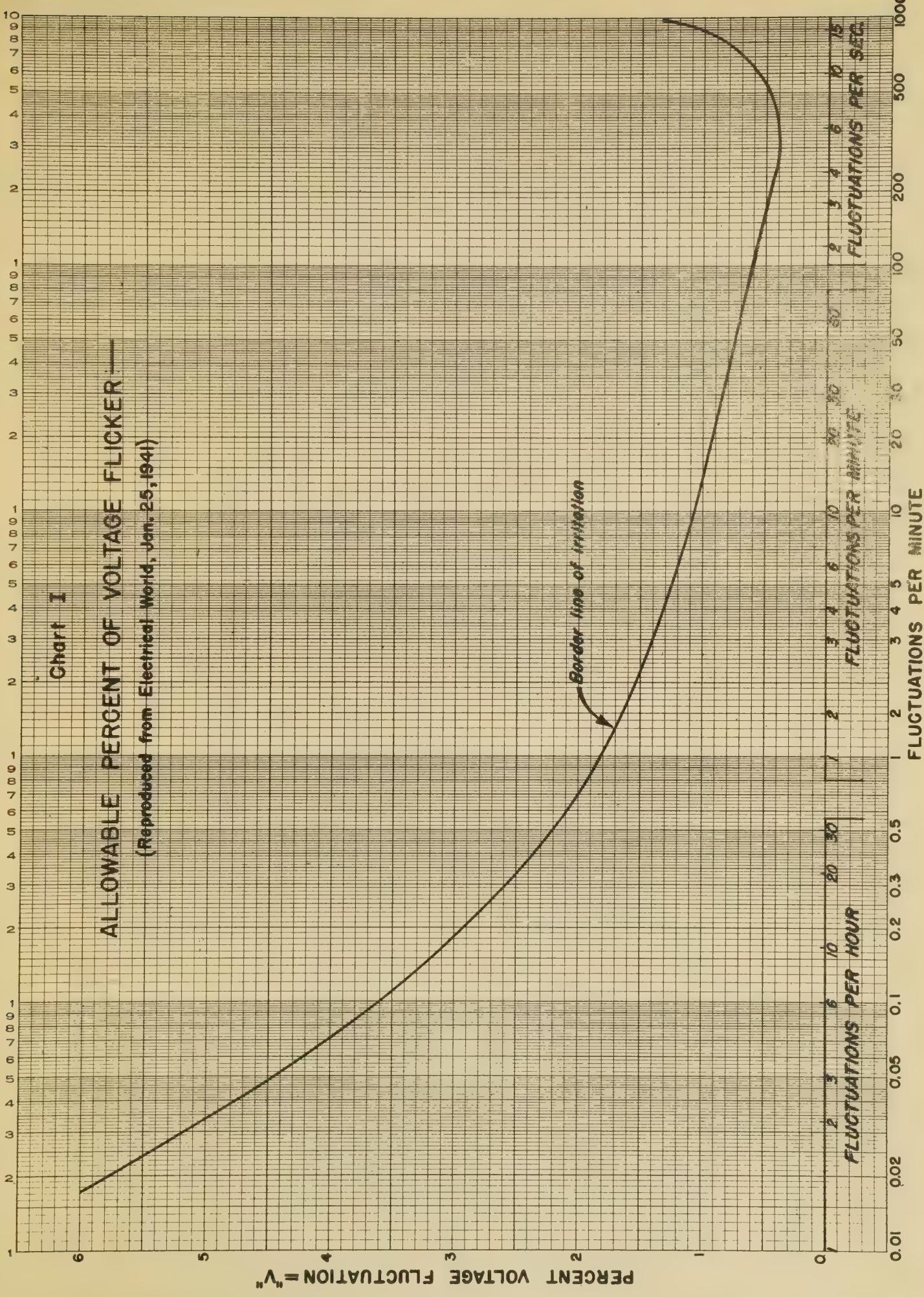
2.3.1. *Exponentially bounded semigroups*. A \mathcal{C}_0 -semigroup $\{\phi_t\}_{t \geq 0}$ is said to be exponentially bounded if there exist constants $M > 0$ and $\omega_0 \in \mathbb{R}$ such that

$$\|\phi_t\| \leq M e^{\omega_0 t} \quad \text{for all } t \geq 0.$$

Chart I

ALLOWABLE PERCENT OF VOLTAGE FLICKER —

(Reproduced from Electrical World, Jan. 25, 1941)



— Chart II —

PERCENT RESISTANCE AND PERCENT REACTANCE
OF
DISTRIBUTION TRANSFORMERS*

TRANSFORMER RATING (KVA.)	ALLIS CHALMERS			GENERAL ELECTRIC			KUHLMAN			LINE MATERIAL			MOLONEY			STANDARD			WAGNER			WESTING- HOUSE		
	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T	% R _T	% X _T		
1.5	2.37	2.08	2.60	2.19	2.06	1.67	3.06	1.48	2.73	1.67	3.06	1.90	2.25	1.31	2.67	0.88	2.26	1.60	2.26	1.60	2.26	1.96	0.88	
3	2.08	2.04	2.27	2.24	2.46	1.60	2.73	1.80	2.40	1.80	2.80	1.50	2.25	1.31	2.67	0.88	2.26	1.60	2.26	1.60	2.26	1.96	0.88	
5	2.25	1.79	2.20	2.18	2.22	1.91	2.50	1.99	2.42	2.10	2.57	2.44	2.20	1.99	2.00	1.32	2.34	1.72	1.81	1.69	2.08	1.69	1.32	
7.5	2.00	2.21	2.15	1.79	2.27	2.33	2.27	2.25	2.27	2.34	2.33	2.33	2.33	2.33	2.33	1.69	2.08	1.69	2.08	1.69	2.08	1.69	1.69	
10	1.85	2.25	2.00	1.96	2.17	2.63	2.17	2.36	2.17	2.26	1.95	2.34	1.83	2.11	1.90	1.63	2.34	1.83	2.11	1.90	1.90	1.90	1.63	
15	1.53	2.24	1.72	2.21	1.78	2.82	1.78	2.66	1.92	2.87	1.82	2.48	1.65	2.29	1.68	1.65	2.48	1.82	2.29	1.65	2.29	1.68	1.65	
25	1.42	2.57	1.51	2.36	1.60	3.19	1.60	2.78	1.53	3.14	1.67	2.90	1.36	2.66	1.47	2.73	2.90	1.36	2.66	1.47	2.73	2.90	1.47	
37.5	1.32	2.79	1.31	2.47	1.38	3.61	1.38	2.89	1.35	2.90	1.49	2.80	1.20	2.66	1.39	3.03	2.90	1.49	2.80	1.20	2.66	1.39	3.03	
50	1.16	2.91	1.22	2.52	1.04	3.80	1.34	2.91	1.38	2.96	1.34	2.90	1.08	3.30	1.29	3.37	2.96	1.34	2.90	1.08	3.30	1.29	3.37	
75	1.09	2.64	1.10	2.47	1.25	3.36	1.25	4.84	1.31	3.10	1.21	3.68	1.16	3.44	1.20	4.80	3.10	1.21	3.68	1.16	3.44	1.20	4.80	
100	1.13	3.07	1.12	2.46	1.23	3.46	1.23	4.84	1.24	3.10	1.26	3.80	1.07	4.41	1.22	3.96	3.80	1.07	4.41	1.22	3.96	3.80	1.07	

* Rating from 1.5 Kva. to 15 Kva. inclusive are R.E.A. type. Rating of 25 Kva. and above are conventional double bushing type.

CHART III

TO CONVERT ALLOWABLE PERCENT VOLTAGE FLUCTUATION
from
TRANSFORMER RATING BASE TO ACTUAL LOAD BASE

1. Use value of V from Chart I.
2. Connect V and W . Mark intersection on A .
3. Proceed from A to E . Mark intersection on W .
4. Connect W and I . Intersection on Z is allowable percent voltage fluctuation under actual load conditions.

Example: 3 - 3 Kva Kuhlman transformers are used to serve the motor in the previous example. The line starting current (from the table of starting current) is 120 amps. The phase current I is equal to $1/3 \times 120 = 40$ amps.

1. Connect $V = 3.6\%$ with $W = 3$ Kva. Mark intersection on A .
2. Proceed from A to $E = 220/1.73 = 127$ volts, phase to neutral. Mark intersection on W .
3. Connect W and $I = 40$ amps. Then $Z = 2.0\%$.

1000 ft. above the surface of the sea.

Will you kindly tell me
what you think?

Very truly yours,
John Muir
Yerkes Observatory
University of Wisconsin
Madison, Wis.
Sept. 20, 1900.

Enclosed herewith is a copy of my paper.

Z = Percent regulation in transformer and conductors.

V = Allowable voltage fluctuation in percent (from Chart I).

W = Kva rating of transformer.

I = Motor starting current.

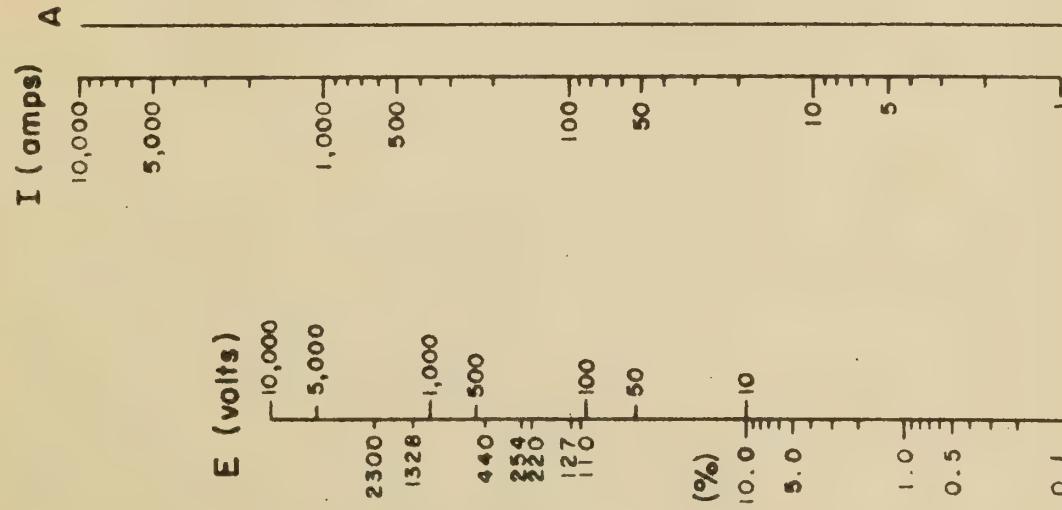
E = Supply voltage {
 $I/\#$ = Voltage between conductors.
 3ϕ = Phase to neutral voltage = Phase to
 phase voltage divided by 1.73}

To Find Z

1. Connect V and W . Mark intersection on A.
2. Connect A and E . Mark intersection on W.
3. Connect intersection on W with I. Read value on Z.

→ Chart III →

E (volts) I (amps) A W (kva.)



To Find Z

1. Connect V and W . Mark intersection on A.
2. Connect A and E . Mark intersection on W.
3. Connect intersection on W with I. Read value on Z.

EQUATIONS of CHART

$$Z = \frac{1000 V W}{I E}$$

$B = Z I$ (B coincident with W)

$$A = BE$$

Z (%)

10

5

1

0.5

0.1

CHART IV

(a). To Determine Percent Voltage Drop in Transformer

1. Use values of R_T and X_T from Chart II.
2. Connect R_T and Power Factor. Read value of intersection on C.
3. Connect X_T and Power Factor. Read value of intersection on D.
4. Percent Voltage drop in transformer: $Z_T = C + D$.
5. Percent Voltage drop in secondary: $Z_S = Z - Z_T$.

(b). To Determine Percent Resistance Drop in Secondary or Service Circuit.

1. Connect Z_S and Power Factor
2. Intersection on R_S is percent resistance drop in secondary or service circuit.

Example: (a) From Chart II, for the transformer in the previous example, $R_T = 2.46\%$, $X_T = 1.60\%$. Starting power factor for the motor, from Table of Starting Currents and Power factors, is 0.13.

1. Connect $R_T = 2.46\%$ and Power Factor. Read 0.3% on C.
2. Connect $X_T = 1.60$ and Power Factor. Read 1.4% on D.
3. $Z_T = 1.4 + 0.3 = 1.7\%$.
4. $Z_S = 2.0 - 1.7 = 0.3\%$.

(b)

1. Connect $Z_S = 0.3\%$ and Power Factor. Read $R_S = 2.4\%$.

the first time, the author has been able to find a complete set of the original drawings.

The author wishes to thank Mr. G. E. Hart, Director of the Royal Ontario Museum, for permission to publish these drawings.

He also wishes to thank Mr. J. W. D. Christie, Curator of the Department of Geology, Royal Ontario Museum, for his help in the preparation of the figures.

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R_T = % Resistance of transformer
 X_T = % Reactance of transformer
 θ = Power factor angle of motor at starting
 Z_T = % Regulation of transformer
 Z_S = % Regulation of service circuit
 R_S = % Resistance drop of service circuit

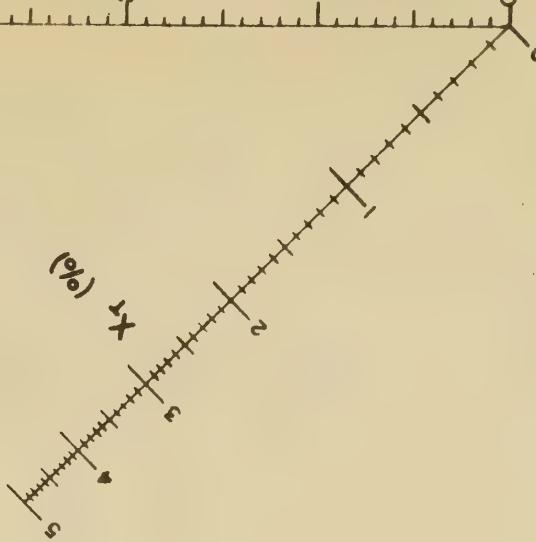
— Chart IV —

POWER FACTOR
($\cos \theta$)

1.0



0.8
0.6
0.4
0.2



7a

To Find R_S :

- (1.) Connect Z_S and $\cos \theta$
- (2.) Read value at intersection on R_S

To Find Z_T :

- (1.) Connect R_T and $\cos \theta$; find value at intersection on C
- (2.) Connect X_T and $\cos \theta$; find value at intersection on D
- (3.) $Z_T = C + D$

C
 Z_S
(%)

CHART V

TO DETERMINE SECONDARY OR SERVICE CONDUCTOR SIZE

1. Connect R_s and E. Mark intersection on F.
2. Proceed from F to I. Mark intersection on R_s .
3. Connect R_s and L. Mark intersection on "r".
4. Intersection on "r" shows resistance of conductor in ohms per 1000 ft. or copper equivalent.

Example: Length of service L = 100 feet.

1. Connect $R_s = 2.4\%$ and E = 127 volts. Mark intersection on F.
2. Proceed from F to I = 40 amps. Mark intersection on R_s .
3. Connect R_s and L = 100 ft.
4. $r = 0.8 \text{ ohms}/1000 \text{ ft.}$ or No. 8 copper equivalent can be used.

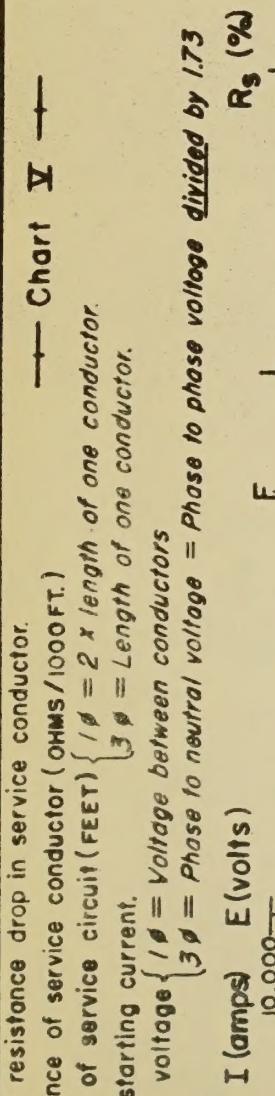
R_s = Percent resistance drop in service conductor.

r = Resistance of service conductor (OHMS/1000FT.)

L = Length of service circuit (FEET) $\{ \begin{matrix} 1/\phi = 2 \times \text{length of one conductor} \\ 3/\phi = \text{Length of one conductor} \end{matrix}$

I = Motor starting current.

E = Supply voltage $\{ \begin{matrix} 1/\phi = \text{Voltage between conductors} \\ 3/\phi = \text{Phase to neutral voltage} = \text{Phase to phase voltage divided by } 1.73 \end{matrix}$



To Find Size of Service Conductor:—

1. Connect R_s and E . Mark intersection on F .
2. Connect F and I . Mark intersection on R_s .
3. Connect intersection on R_s with L .

Value on "r" line shows OHMS / 1000 FT. or COPPER EQUIVALENT.

EQUATIONS OF CHART

$$R_s = \frac{f L I}{10 E}$$

$$R_s E = F$$

$$G I = F \quad (G \text{ and } R_s \text{ coincident})$$

$$r \frac{L}{10} = G$$

